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~~COPY 3 OF 4~~

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PALEONTOLGICAL INVENTORY & ASSESSMENT
of the
TRINIDAD
KNOWN RECOVERABLE COAL RESOURCE AREA
BUREAU OF LAND MANAGEMENT
by
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12/1/80

D.W.F.

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INTRODUCTION

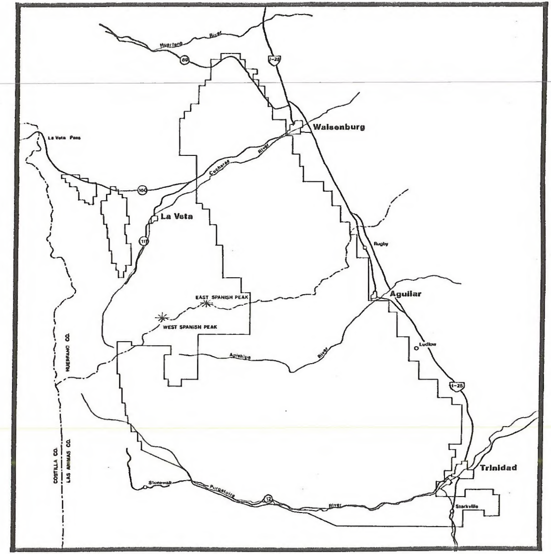
This study is the result of Bureau of Land Management contract No. CO-050-~~PH9-256~~ PL-0-159, providing for a paleontological inventory and assessment of the Trinidad Known Recoverable Coal Resource Area (Trinidad KRCRA)(Index Map). The study is a part of an on-going program conducted under the auspices of the Canon City District office. Work commenced on June 27, 1980 and is completed this date, December 1, 1980. While I benefited greatly greatly from discussions with numerous individuals, the field work and report compilation were conducted by me, and I remain solely responsible for the content.

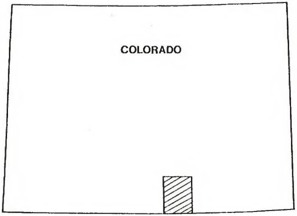
Specifications for this inventory call for classification of all Federal "mineral" lands within the KRCRA into three catagories which recognize the scientific value and importance of fossil occurrences. The classification is as follows:

Class 1 Immediate detailed study is needed. Fossils of scientific interest are exposed on the surface or are very likely to be discovered with detailed field work in the area. If the site is under immediate threat of damage or loss, mitigation measures must be taken. Type sections and type localities should be described.

Class 2 There is evidence of fossilization, but the presence of scientific value has not been established, and is not anticipated. Detailed study may be desirable in the future for

# INDEX MAP




Area Location

## Paleontological Inventory and Assessment

## Trinidad KRCRA

0 5 10 MILES

0 5 10 KILOMETERS

D.W.FISCHER 12-1-80

the evaluation of all types of fossil collecting. This classification may be used in identifying recreational values in fossils.

Class 3 Little likelihood of finding fossils of use. No further considerations of fossils necessary unless future discoveries require a change of classification.

All of the formations present in the study area with the exception of the igneous intrusive rocks are known to be fossil-bearing and documented either within the area or elsewhere in the region and vicinity. All of these fossil occurrences are of some scientific interest. In the strict sense, each of these formations can be designated at least as Class 2, however, additional factors bearing on their classification are examined more fully in discussion further on. The emphasis of this study focuses on the documented fossil occurrences and localities and investigates the likelihood for significantly more important discoveries.

Field work in the study area was conducted for the purpose of recovering reported localities, to determine the relationship of formation outcrops to the location of Federal mineral lands, and to observe and verify the relative abundance, mode, and quality of preservation of the fossil material. The botanical fossils present in certain of the formations are abundant, and numerous additional localities other than those reported here could be established. An effort to locate indications of vertebrate fossils was not successful.

## GEOLOGY

The Raton Basin is an elongate structural feature which reaches from Cimarron in northern New Mexico to Huerfano Park, Colorado in the north. The basin is bounded by the southern Sangre de Cristo Mountian range on the West and is defined by a prominent erosional escarpment on the east. Formations ranging from Upper Cretaceous to Eocene in age outcrop within the Trinidad KRCRA portion of the basin. Middle Tertiary igneous intrusives have invaded the sedimentary section, forming the heart of the Spanish Peaks and their attendant radial dike swarms.

The boundaries of the Trinidad KRCRA have been drawn so as to include those areas underlain by coal, and as a result, generally exclude the older formations that outcrop at the area margins and the igneous rocks central to the area. Figure 1. shows a general geologic column for the formations present in the study area.

The depositional environments of the uppermost Pierre Shale progressing up through the Tinidad Sandstone and the Vermejo and Raton Formations are interpreted to represent a regressive sequence advancing from the west to the east. Models of sequential marine delta sedimentation and transition into fluvial and continentaly dominated environments have been successfully applied to the stratigraphy (Billingsley 1977, Pillmore and Maberry 1976, among others, and Romeo Flores - personal communication).

While the bulk of the Pierre strata are characterized by fissile black shales, the uppermost Pierre which is restricted

to the eastern and western margins of the study area, is represented by carbonaceous shales, siltstones, and fine-grained sandstones. Sedimentary structures in the uppermost units such as subparallel laminations, signs of strong bioturbation, and Asterosoma trace fossils in conjunction with the lithologies mark the first influence of delta contruction. These prodelta sediments grade upward into a transition zone of more continuous and extensive sands representing the lower delta front and the contact with the overlying Trinidad Sandstone.

The main accumulation of deltaic sediment is contained in the Trinidad. The lower delta front facies show principally subparallel bedded, fine-grained and clay rich sandstones and siltstones while the upper delta front facies exhibit low angle, crossbedded sandstones with Ophiomorpha, Diplocraterion, and Skolithos trace fossils (Pillmore and Maberry 1976).

The topmost beds of the Trinidad bear higher angle cross-bedding, more coarse-grained sandstones, land derived elements such as carbonized wood fragments, and a marked absence of traces from marine burrowers, all which are attributable to chiefly freshwater distributary channel features of the deltaic system (Billingsley 1977). Alternately, Pillmore and Maberry (1976) propose a continental, beach and aeolian dune environment for these upper beds.

Trinidad outcrops are essentially confined to a narrow band running along the eastern erosional escarpment of the basin.

Beds of the Vermejo Formation which overlie the Trinidad denote a full transition to the delta plain environment. The sediments are largely composed of sandstones and shales along

with coal beds. Lithologic sequences vertically record developments of channel margin deposits, crevasse splays with related sand bodies, and interdistributary coal swamps (Billinglsey 1977). Delta plain and fluvial depositional conditions prevailed through Vermejo time until increased uplift to the west resulted in actual erosion of some of the upper Vermejo beds.

Subsequent to this brief erosive phase, deposition resumed leaving the interval marked as a basal conglomerate in the first beds of the Raton Formation. It was long thought that this unconformity also marked the Cretaceous - Paleocene or Mesozoic - Cenozoic boundary, however, botanical evidence suggests that the boundary is located above the basal conglomerate, several hundred feet up into the Raton.

Dominant lithologies in the formation include more arkosic sandstones than those below, shales, and coal beds corresponding to river, floodplain, and swamp environments. Plant fossils are found over the entire vertical range of the Raton, yet are considerably more abundant in the upper parts as are the coals (Ash and Tidwell 1976).

Coincident with deposition of the Raton, upland terranes to the west continued to shed sediments toward the east, forming and intertonguing of the Poison Canyon Formation with the Raton. Sediment for most of the delta and delta plain wedge originated in areas to the west in what is now the San Luis Valley region. With this overall progradation and migration of shorelines to the east, the different depositional environments which were originally geographically adjacent

became stacked vertically (Billingsley 1977).

Poison Canyon deposits are characterized by coarse-grained detritus and evidence of oxidizing depositional conditions. Sparse coals along with plant fossils are present in the lower sections. The upper parts contain numerous pebble and actual cobble or boulder conglomerates demonstrating significantly increased uplift in the source areas.

Outcrops of the Poison Canyon Formation occupy large interior portions of the Trinidad KRCRA.

The Cuchara Formation of Eocene age unconformably overlies the Poison Canyon and consists largely of basin fill debris. The representative sediments are oxidized sandstones and interbedded shales and occasional conglomerates which may actually have been derived from exposed Poison Canyon rocks (Johnson, Dixon, and Wanek 1966).

Also unconformably, the beds of the Huerfano Formation in turn overlie those of the Cuchara. In contrast to the piedmont-type of deposits of the Cuchara, the Huerfano is characterized by variegated shales which correspond to river floodplain and lowland conditions. Although both units are quite thick, their existing outcrops are limited to Huerano Park in the north and to areas south of and adjacent to the Spanish Peaks.

The geologic history of the Raton Basin as pertains to the study area culminates with episodic igneous and mountain building activity through the Tertiary, structural formation of the basin, and eventual valley cutting with depostion of Quaternary alluvium.

PALEONTOLOGY

The upper sections of the Pierre Shale (Upper Cretaceous) as exposed on the eastern and western edges of the Trinidad KRCRA contain a fossil fauna dominated by molluscs and indicative of an open marine shelf environment. All elements of the fauna as reported (Lee 1917, Cobban 1976) are common and well-known forms (Table 1.). Apparently there are indications of at least one vertebrate (Mososaurus sp. in Lee 1917), however, their occurrence in the Pierre are rare. A complete specimen would be an important discovery but unlikely to be found within the study area. For the most part, only the uppermost beds of the Pierre are included within the boundaries of the study area, and they typically produce only sparce fossils. Biologic activity, however, is recorded by the intense bioturbation in certain facies and the presence of abundant Asterosoma and Skolithos trace fossils.

Given the criteria for classification, the Pierre Shale is considered Class 2. No areas in particular within the KRCRA are appropriate for possible public collection.

The Trinidad Sandstone which overlies the Pierre is also considered Class 2 even though it produces very few fossils of paleontological importance. Trace fossils are quite common and are dominated by Ophiomorpha throughout the vertical range. As a matter of fact, the presence of Ophiomorpha is a good indicator for identifying the Trinidad (Pillmore and Maberry 1976).

TABLE 1. Invertebrate Fossils (Species List unrevised) From the Raton Basin and Region.

Lee (1917)

Pierre Shale:

_Ancyloceras_ sp.
_Anisomyon_ ? sp.
_Anomia_ ? sp.
_Avicula_ sp.
_Avicula linguiformis_
_Baculites ovatus_
_Baculites compressus_
_Cardium_ sp.
_Crassatellites cimarronensis_
_Crenella_ sp.
_Cucullaea_ sp.
_Dentalum_ sp.
_Fasciolaria_ sp.
_Heteroceras_ sp.
_Heteroceras cheyennense_
_Inoceramus barabini_
_Inoceramus oblongus_
_Inoceramus sagensis_
_Inoceramus vanuxemi_
_Leda_ sp.
_Leda scitula_
_Lima_ sp.
_Liopistha undata_
_Lucina occidentalis_
_Lucina_ sp.
_Lunatia_ sp.
_Mactra_ sp.
_Margarita nebrascensis_
_Martesia_ ? sp.
_Nautilus dekayi_
_Nemodon_ sp.
_Nucula_ sp.
_Odontobasis_ ? sp.
_Ostrea pellucida_
_Ostrea_ sp.
_Pinna_ sp.
_Placenticeras_ sp.
_Placenticeras intercalare_
_Placenticeras whitfieldi_
_Ptychoceras_ sp.
_Pyrifusus_ ? sp.
_Scaphites nodosus_
_Syncyclonema rigida_
_Tancredia americana_
_Volutoderma_ sp.
Fish remains
_Mososaurus_ sp.

TABLE 1. - continued

Trinidad Sandstone:

| | |
|---|---|
| Anomia ? sp. | Mactra sp. |
| Avicula nebrascana | Mytilus ? sp. |
| Chlamys nebrascensis | Ostrea pellucida |
| Inoceramus barabini | Ostrea sp. |
| Inoceramus sagensis | Panopaea ? sp. |
| Legumen ? sp. | Tellina scitula |
| Lucina sp. | Tellina sp. |
| Mactra warreniana | Mososaurus sp. |

Pillmore and Maberry (1976)

Trace Fossils - Trinidad Sandstone and transition zone of the Pierre Shale:

Diplocraterion
Ophiomorpha = Halymenites of older reports
Asterosoma
Teichichnus
Aulichnites
Desmograpton
Thallassinoides

The trace, Ophiomorpha, is the same Halymenites cited in the older reports in which it was believed to be an algae-like organism. The distinctive corncob texture of the fossil apparently results from packing of fecal pellets into the sides of inclined burrows which are attributed to a burrowing shrimp comparable to the modern Calianassa. Along with Ophiomorpha, other trace fossils of the Trinidad are Asterosoma, which are long, slender and usually vertical burrows; Diplocraterion, which appear as a series of stacked, u-shaped tubes in cross-section; Teichichnus, with a curved, scimitar shape; Aulichnites, a grazing trail found on bedding planes; Thallassinoides, which are y-shaped tubes; and Desmograpton, a horizontally oriented h-shaped chain of burrows (Pillmore and Maberry 1976)(Table 1.).

Pillmore and Maberry also identify a problematic fossil resembling a palm root bole (cf. Nathorstiana). Some large chunks of carbonized wood showing boring by a Toredo - like organism have also been found which, along with the palm root, are believed to have been rafted into place. A few specimens each of six types of plant fossils have been found in areas north of the study area. Romeo Flores and Charles Pillmore both report finding poorly preserved and unidentified bivalve fossils of a form suggesting brackish water conditions. Lee (1917) notes a fairly large list of invertebrates (Table 1.), however, many of these can probably be relegated to the top part of the Pierre.

It seems curious that more fossils have not been found in the Trinidad. The bivalves among other possible fossils should receive more study. While the trace fossils provide an

important basis for interpreting depositional environments, most of the traces are not amenable to collection. Considering all these factors, the formation is designated as Class 2.

Plant fossils from the Vermejo Formation have been known for quite a long time. Early surveys into the area revealed many different types of leaves which impressed their discoverers with their similarity to existing plants (Abert 1848, LeConte 1868, Lesquereaux 1878, and Newberry 1883). The most comprehensive study of the Vermejo flora was made by Knowlton (1917), and although his taxonomy has been extensively revised, his work remains as the primary source of information.

The Vermejo was deposited in a delta plain environment, and elements of the flora tend to reconstruct a diverse setting under a non-seasonal, warm temperate or subtropical climate. Nearly one hundred different species are recognized in the flora with angiosperms prevailing over those of the gymnosperms. Preservation by impressions and carbonization is mostly of leaves.

Among the dicotyledonous angiosperms, figs (Ficus) and willows (Salix) are the dominant forms. Other elements present in lesser numbers are laurels (Laurus), magnolia (Magnolia), grape (Vitis), sycamore (Platanus), walnut (Juglans), oaks (Dryophyllum), beech (Fagales), bittersweet (Celastrus), breadfruit (Artocarpus), and honeysuckle (Viburnum). The monocots are represented by some palms (Sabalites) and by Sparganium and Canna. (Knowlton 1917 and Ash and Tidwell 1977)

TABLE 2. The Vermejo Flora. (unrevised) Knowlton (1917)
(excluding species from the Florence District)

| | |
|---|---|
| Abietites dubius | Paleoaster inquirenda |
| Artocarpus dissecta | Phyllites aurantiacus |
| Brachyphyllum cf. B. macrocarpum | P. leei |
| Chondrites bulbosus | P. nanus |
| C. subsimplex | P. populoides |
| Caulerpites incrassatus | P. rosaefolius |
| Asplenium ? coloradense | P. sapindus |
| Cupressinoxylon coloradense | P. walsenburgensis |
| Canna magnifolia | P. vermejoensis |
| Credneria protophylloides | P. ratonensis |
| Colutea speciosa | Quercus gardneri |
| Celatrus ? sp. | Rosellinites lapideus |
| Cissites panduratus | Rhamnus salicifolius |
| Diospyros ? leei | Sequoia reichenbachi |
| Ficus haddeni | S. obovata |
| F. leei | Sabal montana |
| F. minima | S. ? ungeri |
| F. ? starkvillensis | Salix gardneri |
| F. praetrinervis | S. plicata |
| F. speciosissima | S. sp.A and sp.B |
| F. wardii | Sterculia coriacea |
| F. gigantea | Taxodium ? sp. |
| Fraxinus ? sp. | Viburnum anomalinervum |
| Geinitzia formosa | V. montanum |
| Hedera rotundifolia | V. crassum |
| Myrica torreyi | V. rhamnifolium |
| Pteris russellii | Vitis ? sp. |
| P. erosa | Woodwardia crenata |
| P. ? sp. | Widdringtonia ? complanata |
| Populus ? neomexicana | Zizyphus palurifolius |
| Phaseolites minutus | |
| Pterospermites undulatus | Liriodendron alatum |
| P. wardii | Sparganium ? sp. |
| P. nervosus | |

Among the gymnosperms, conifers were a part of the floral assemblage and are recognized by Sequoia, Metasequoia, Widdringtonia, Araucarites, and by cypresses (Taxodium), and firs (Abietites). (Knowlton 1917 and Ash and Tidwell 1976) Fossil wood has been described (Cupressinoxylon and a species of Platanus), however, conditions appear not to have been favorable for widespread preservation by silicification. Other gymnosperms in the flora include the ferns: the Osmundaceae, the Polypodiaceae, the Gleicheniaceae, and the Schizaeaceae families are all represented.

Microfossil palynomorphs have been collected from Vermejo coals in the Florence Field and described by Clark (1965 and 1966). Less than 10% of the pollen in his samples is gymnosperm while 50% and 40% are angiosperm pollen and fern spores, respectively. Clark suggests mesic, warm - temperate to subtropical climatic conditions were in effect. Undoubtedly, palynomorph extractions from beds in the Trinidad KRCRA could be made and might produce useful information, however, Clark was unable to use them for stratigraphic zonation.

The Raton flora is similar in many aspects to that of the Vermejo. Most notably different are the truly abundant palms, many of which possess extremely large fronds as much as six feet or greater in length. Relatively warm - temperate or subtropical conditions on the delta plain and lowland areas are in evidence.

Knowlton's (1917) Raton flora as revised by Brown (1962) contains over 50 species. (Table 3.)

TABLE 3. The Raton Flora With Revisions Following Brown (1962).

<u>Allantodiopsis erosa</u>
<u>Blechnum anceps</u>
<u>Dryopteris lakesi</u>
<u>Lastrea goldiana</u>
<u>Anemia elongata</u>
<u>Isoetites horridus</u>
<u>Alismaphyllites grandifolius</u>
<u>Chamaedora danae</u>
<u>Paleoreodoxites plicatus</u>
<u>Sabal grayana</u>
<u>Sabal imperialis</u>
<u>Sabal powelli</u>
<u>Carya antiquorum</u>
<u>Juglans berryana</u>
<u>Castanea intermedia</u>
<u>Artocarpus lessigiana</u>
<u>Ficus affinis</u>
<u>Ficus artocarpoides</u>
<u>Ficus minutidens</u>
<u>Ficus planicostata</u>
<u>Ficus uncata</u>
<u>Platanus nobilis</u>
<u>Platanus raynoldsi</u>
<u>Laurophyllum caudatum</u>
<u>Laurophyllum perseanum</u>
<u>Laurus socialis</u>
<u>Persea brossiana</u>
<u>Nymphaea leei</u>
<u>Cercidiphyllum articum</u>
<u>Magnolia berryi</u>
<u>Magnolia magnifolia</u>
<u>Magnolia regalis</u>
<u>Magnolia rotundifolia</u>
<u>Eucommia serrata</u>
<u>Prunus coloradensis</u>
<u>Staphylea minutidens</u>
<u>Acer fragile</u>
<u>Rhamnus goldiana</u>
<u>Zizyphus fibrillosus</u>
<u>Cissus marginata</u>
<u>Cissites rocklandensis</u>
<u>Vitis olriki</u>
<u>Pterspermites cordatus</u>
<u>Nyssa alata</u>
<u>Apocynophyllum lesquereauxi</u>
<u>Phyllites pagoensis</u>
<u>Carpolithes spinosus</u>
<u>Palmocarpon commune</u>
<u>Palmocarpon compossitum</u>
Roots with rootlet scar pits
Fossil wood

The original list included as many as 12 different species of Ficus, 9 of Magnolia, and 9 of Juglans, most all of which were synonomized by Brown.

The Angiosperms consist essentially of broad-leaved varieties such as walnut, oak, cottonwood, sycamore, and magnolia. Ferns are prevalent as Dryopteris, Allantodiopsis, Isoetites, and Blechnum, (Knowlton 1917 and Ash and Tidwell 1976). The problematic fossil, Paleoaster, which is thus far restricted to Cretaceous age rocks, occurs in the lower parts of the formation and establishes the Cretaceous - Paleocene boundary.

Of the palms which are so profuse, only a few different species have been described. Sabalites is the prevalent type. Other monocots include palm-like plants and Alismaphyllites.

The Raton Formation is considered Class 2 in reference to this contained flora. Localities might be developed for possible public collecting.

Fossils in the overlying Poison Canyon Formation are sparce, although some localities yield excellent specimens. Knowlton's (1917) referenced localities (Table 4.) for plant fossils are somewhat in question and a few may belong in the Raton. Due to the intertonguing of the two formations, correctly placing the formation boundaries is difficult. At any rate, the plant fossils contained in the lowest parts of the Poison Canyon are virtually indistinguishable from those of the upper Raton. Ficus is dominant and occurs

along with Laurus, Palmocarpon, Cissus, and Zizyphus.

The formation is designated Class 2.

The Eocene aged Cuchara and Huerfano Formations have not as of yet yielded fossil material of record from locations within the study area. In Huerfano Park to the north, however, important vertebrate discoveries have been made. Much of this work has been conducted by field parties from the University of Colorado. Robinson (1960 and 1963) reports on fossil mammals from the formations which among them includes Sinopa, a small, fox-sized carnivore. Marsupials (Simpson 1968) and tapirs (Radinsky 1966) are also present.

Both the Cuchara and the Huerfano are designated as Class 2, yet, with in effect a proviso which is discussed below.

## DISCUSSION AND RECOMMENDATIONS

### The Pierre Shale

The Pierre is considered Class 2 which is in keeping with its previous classification in other regions of the Royal Gorge Planning Area. The formation produces numerous fossils, however, in the study area they are limited and are all of well-known forms. Vertebrate remains are rare. No areas seem appropriate for public collection.

### The Trinidad Sandstone

The Trinidad is considered Class 2 although it is not highly fossiliferous. A number of Lee's (1917) species (Table 1.) belong in the Pierre. Most of the fossils present

are traces of burrowing organisms, and plant fossils are uncommon. A small bivalve fauna needing additional work has been found, yet, no critical scientific value has been established. Trace fossils are more appropriate for observation than collection, and as with the Pierre, no areas are suitable for public collection.

The Vermejo and Raton Formations

The Vermejo and Raton are both designated Class 2 in consideration of their fossil floras. The plant fossils, often beautifully preserved, are important paleontologically, yet, they are fully abundant enough so as not to need special protection or consideration. The numerous coal beds in these formations are of course fossil material themselves. Each of the formations of the Trinidad through the Raton has, based on environments of deposition, a certain chance for having vertebrate or other significantly more unique or important fossil occurrences. This would be under a relatively low probablility, however, and until such are found, the Class 2 designation is correct.

Areas for possible public collecting of fossils within the Vermejo and Raton probably can be designated. Factors such as access to sites, abundance and type of preservation of fossil material, land ownership, and exposure should all be taken into account. It would be anticipated that the type of public interested in such an area would be the "informed" amateur collector or group who would most likely not cause undue damage. It may be best to derive such locations by

detailed local study. Many of the documented localities described as being very fossiliferous are not readily available to the public. Many are in coal mines or on mine dumps and often on private lands.

## The Poison Canyon Formation

Fossils are not common in the Poison Canyon. Plant fossils are present, and the formation should be considered as Class 2. The formation, like the underlying two, bears a certain chance of producing important finds, however, the likelihood of such is little. Some localities do have very nicely preserved plant specimens, yet, none are quite appropriate for the public.

## The Cuchara and Huerfano Formations

Based on important vertebrate occurrences in regions adjacent to the study area, these formations are given Class 2 status. It is important to point out, however, that there are currently no known fossil occurrences in the units from within the Trinidad KRCRA. This may be due in part to the fact that it has recieved less field study, yet,significant lithological differences between these areas and Huerfano Park do exist. In general, the facies of both formations tend to become more coarse-grained towards the west and southwest which may adversely effect the favorability for preservation. In any case, Class 2 is suggested and it is recognized that the classification could very easily be upgraded or downgraded depending upon future work. There are no areas for public collection.

In summary, all of the formations exposed in the Trinidad KRCRA are fossil-bearing either within the area or adjacent to the area. All of the Federal mineral lands in the KRCRA, with the exception of some Class 3 areas occupied by igneous rocks, are considered Class 2 and are not in need of immediate detailed work or special protection. Classification for some formations may eventually be upgraded or downgraded with further work. Plant fossil collecting sites might be chosen with careful consideration.

## ACKNOWLEDGMENTS

I would like to express my sincere thanks to Roger Underwood of the Bureau of Land Management for his kind and able assistance on this study, to the numerous other workers who contributed their ideas and information freely, and to Carol Erickson for her help in the preparation of the report.

TABLE 4. Referenced United States Geological Survey Fossil Localities in the Trinidad KRCRA and Vicinity.

| Locality No.: | Location and Description: |
|---|---|
| 5682 | SW¼, NW¼, sec. 9, T.27S., R.67W. Raton Formation, near the townsite of Strong. |
| 5680 | SE¼,SE¼, sec. 23, T.27S., R.67W. Vermejo Formation, one mile south of Shumway. |
| 5676 | SW¼,NE¼, sec. 8, T.28S., R.66W. Vermejo Formation, the McAnily Mine dump. |
| 5679 | SW¼,NW¼, sec. 17, T.28S., R.66W. ½ mile east of the Rockland Mine, several feet above the Solar coal. |
| 5677 | SE¼,SE¼, sec. 18, T.28S., R.66W. Vermejo Formation, from the dump of the Rock-land Mine, above the Robinson coal. |
| 5044 | NE¼,NW¼, sec. 21, T.28S., R.66W. Vermejo Formation, from the roof of the Cameron Mine. |
| 5130 | SE¼,SE¼, sec. 21, T.28S., R.66W. Vermejo Formation, Ravenwood Mine south of Walsenburg, 10' above base. |
| 5131 | NW¼,NW¼, sec. 28, T.28S., R.66W. Vermejo Formation, 3 miles south of Walsenburg, 10' above base. |
| 5678 | NE¼,NW¼, sec. 30, T.28S., R.66W. Poison Canyon Formation, above base. |
| 5683 | NE¼,NW¼, sec. 9, T.29S., R.66W. Raton Formation, 3 miles south of Walsenburg, 4 miles west of Mayne, 300' above base. |
| 5685 | SE¼,NE¼, sec. 30, T.29S., R.65W. Vermejo Formation, near the Rouse Mine. |
| 5128 | |
| 5696 | NW¼,NW¼, sec. 8, T.30S., R.65W. Raton Formation, near Rugby |
| 5684 | SE¼,NE¼, sec. 20, T.30S., R.65W. Raton Formation, dumps from the Green Canyon Mines, Gonzales Canyon, 330' to 475' above base. |

TABLE 4. -continued

| | |
|---|---|
| 5123<br>5122 | SW¼,SW¼, sec. 19, T.30S., R.65W.<br>Raton Fm., Poison Canyon Fm.(?), near Aguilar. |
| 5118 | SE¼,SW¼, sec. 20, T.30S., R.65W.<br>Raton or Poison Canyon (?) Fm., near Aguilar. |
| 5046 | SW¼,SW¼, sec. 24, T.30S., R.66W.<br>Poison Canyon Fm., 5 miles west of Aguilar. |
| 5124 | NE¼,NE¼, sec. 10, T.31S., R.66W.<br>Poison Canyon Fm., 2.5 miles northwest of Trujillo, 400' above base. |
| 5689 | NW¼,SW¼, sec. 8, T.31S., R.65W.<br>Raton Fm., 3.5 miles southwest of Aguilar. |
| 5687 | SW¼,SE¼, sec. 11, T.31S., R.66W.<br>Raton Fm., 1 mile northwest of Trujillo, 100' below top. |
| 5688 | SE¼,NE¼, sec. 18, T.31S., R.65W.<br>Raton Fm., 1.5 miles northwest of Abeton, 200' below top. |
| 5686 | NE¼,NE¼, sec. 24, T.31S., R.66W.<br>½ mile west of Abeton, north of wagon road, 100' below top of Raton Fm.. |
| 5690 | SE¼,SE¼, sec. 16, T.31S., R.65W.<br>Raton Fm., mine dump near Delagua, 600' above base. |
| 5045<br>5121 | NW¼,SE¼, sec. 11, T.32S., R.66W.<br>Poison Canyon Fm., 7 miles southwest of Berwind, 400' above base. |
| 5107 | NW¼,NE¼, sec. 2, T.32S., R.65W.<br>Top of Raton Fm. or base of Poison Canyon Fm., 4 miles southwest of Berwind. |
| 5120 | SW¼,SW¼, sec. 3, T.32S., R.65W.<br>Top of Raton Fm. or base of Poison Canyon Fm., 4 miles southwest of Berwind. |
| 5095 | NW¼,NE¼, sec. 11, T.32S., R.65W.<br>Top of Raton Fm. or base of Poison Canyon Fm., 4 miles southwest of Berwind. |

TABLE 4. - continued

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|---|---|
| 5672 | NE¼,NE¼, sec. 9, T.29S., R.69W. Vermejo Fm., at Oakdale. |
| 5673<br>5674 | NE¼,NE¼, sec. 16, T.29S., R.69W. Raton Fm. (?), near the Occidental Mine. |
| 5675 | SW¼,NE¼, sec. 35, T.29S., R.69W. Poison Canyon Fm.(?), southwest of LaVeta, Middle Fork Cuchara River. |
| 5693 | SW¼,NW¼, sec. 13, T.32S., R.64W. Raton Fm., north of Bowen. |
| 5101 | NE¼,NE¼, sec. 23, T.32S., R.64W. Raton Fm., north of Bowen. |
| 5691 | NE¼,SW¼, sec. 16, T.32S., R.64W. Vermejo Fm., dump of the Forbes Mine, south of Majestic. |
| 5694 | NW¼,NW¼, sec. 26, T.32S., R.64W. Vermejo Fm., roof shale of abandoned mine. |
| 5110 | SW¼,NW¼, sec. 27, T.32S., R.64W. Vermejo Fm., Powell Arroyo, near top. |
| 5111<br>5112 | SE¼,SE¼, sec. 21, T.32S., R.64W. Raton Fm., Powell Arroyo. |
| 5692<br>5794<br>5496 | NW¼,SE¼, sec. 24, T.32S., R.64W.<br>No. 5692 - Vermejo Fm., Bowen Mine, roof shale.<br>No. 5794 - Raton Fm., near Bowen, 20' sandstone.<br>No. 5496 - " " " " " " . |
| 5102 | SW¼,NE¼, sec. 25, T.32S., R.64W. Raton Fm., near Bowen. |
| 5094 | SW¼,NE¼, sec. 25, T.32S., R.64W. Raton Fm., near Bowen. |
| 5100 | NE¼,NW¼, sec. 6, T.33S., R.64W. Raton Fm., 4 miles northwest of Trinidad, 200' above base. |
| 5097 | SE¼,SW¼, sec. 10, T.33S., R.64W. Raton Fm., northwest of Trinidad, near base. |
| 5098 | NE¼,NW¼, sec. 15, T.33S., R.64W. Vermejo Fm., west of Trinidad. |

TABLE 4. - continued

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|---|---|
| 5796 | NE¼,SE¼, sec. 11, T.34S, R.64W. Raton Fm., south of Starkville, Raton Canyon, near base. |
| 5797 | SE¼,NE¼, sec. 14, T.34S., R.64W. (off south margin of overlay map) Raton Fm., Raton Canyon, 200' above base. |
| 5706 | NW¼,NE¼, sec. 36, T.33S., R.64W. Vermejo Fm., McLaughlin Mine near Starkville. |
| 5707 | SE¼,SE¼, sec. 36, T.33S., R.64W. Vermejo Fm., dump of the Starkville Mine. |
| 5099 | NE¼,NW¼, sec. 32, T.33S., R.63W. Vermejo Fm., 1.5 Miles southwest of Engle, floor of the Fisher's Peak Mine, 400' to 500' above base. |
| 5710 | SE¼,NE¼, sec. 34, T.33S., R.63W. Vermejo Fm., southeast of Trinidad, dump of the Grey Creek Mine, roof of 6' coal. |
| 5103<br>5104<br>5105<br>5702<br>5703<br>5699 | NW¼,SE¼, sec. 14, T.33S., R.65W. Raton Fm., in Reilly Canyon near Cokedale, lower 200' of formation. |
| 5700 | SW¼,SW¼, sec. 24, T.33S., R.65W. Raton Fm., in Reilly Canyon near Cokedale, lower 200' of formation. |
| 5701 | NW¼,SW¼, sec. 24, T.33S., R.65W. Raton Fm., in Reilly Canyon near Cokedale, lower 200' of formation. |
| 5698 | NW¼,SE¼, sec. 25, T.33S., R.65W. Vermejo Fm., dump of the Cokedale Mine. |
| 5704 | NW¼,SE¼, sec. 31, T.33S., R.64W. Raton Fm., Purgatoire Canyon south of Cokedale. |
| 5795 | W½ (?), sec. 6, T.34S., R.64W. Raton Fm., Purgatoire Canyon south of Cokedale. |
| 5798 | SE¼,NW¼, sec. 25, T.33S., R.66W. Raton Fm., at Primero, 600' above base. |

TABLE 4. - continued

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|---|---|
| 5799<br>5825 | NE¼,NE¼, sec. 10, T.33S., R.67W. Raton Fm., Wet Canyon, 4 miles north of Weston, No. 5799 at 50' below top and No. 5825 at 100' below top. |
| 5106<br>5114 | NE¼,NW¼, sec. 19, T.33S., R.67W. Raton Fm., east of Stonewall, upper part. |
| 5800 | NE¼,NW¼, sec. 4, T.33S., R.68W. Vermejo Fm., north of Stonewall, south of the North Fork. |
| 5801 | NE¼,SW¼, sec. 33, T.32S., R.68W. Raton Fm., north of Stonewall, north of river. |
| 5113 | SE¼,SE¼, sec. 7, T.32S., R.68W. Raton Fm., 2 miles south of Dean. |

Invertebrate Localities:

| | |
|---|---|
| 5592 | SE¼,NW¼, sec. 15, T.29S., R.65W. Pierre Shale, 2¼ miles east of Monson, south side of Santa Clara Creek. |
| 5591 | NW¼,SE¼, sec. 16, T.29S., R.65W. Pierre Shale, 1.75 miles east of Monson, south of Santa Clara Creek. |
| 5590 | NW¼,SW¼, sec. 17, T.29S., R.65W. Trinidad Sandstone, railroad cut ½ mile east of Prior Mine near Rouse. |
| 5565<br>5565a | SE¼,NE¼, sec. 25, T.32S., R.64W. Pierre Shale, near Bowen, No. 5565 at 150' below top and 5565a at 275' below top. |
| 5612 | NW¼,NW¼, sec. 30, T.32S., R.63W. Pierre Shale, 1 mile south of Bowen, near top. |
| 5667 | SW¼,NW¼, sec. 1, T.33S., R.64W. Pierre Shale, quarry north of Trinidad. |
| 6511 | SW¼,NE¼, sec. 6, T.33S., R.63W. Pierre Shale, 2 miles northeast of Trinidad. |

TABLE 4. - continued

(invertebrate localities)

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|---|---|
| 6510 | SE¼,SE¼, sec. 7, T.33S., R.63W.<br>Pierre Shale, northeast edge of Trinidad. |
| 5668 | SE¼,SW¼, sec. 20, T.33S., R.63W.<br>Pierre Shale, 1 mile west of Engle. |

Botanical Localities near Stonewall:
(outside Trinidad KRCRA)

| | |
|---|---|
| 5802 | SE¼,NW¼, sec. 22, T.34S., R.68W.<br>Raton Fm., near Tercio, 400' above base. |
| 5803 | SE¼,NW¼, sec. 22, T.34S., R.68W.<br>Raton Fm., near Tercio, 200' above base. |
| 5804 | SW¼,NW¼, sec. 27, T.34S., R.68W.<br>Vermejo Fm.?, 1 mile southeast of Stonewall. |
| 5805 | SW¼,SW¼, sec. 29, T.34S., R.68W.<br>Vermejo Fm.?, 1 mile south of Stonewall,<br>in the lower 50' of the formation. |

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